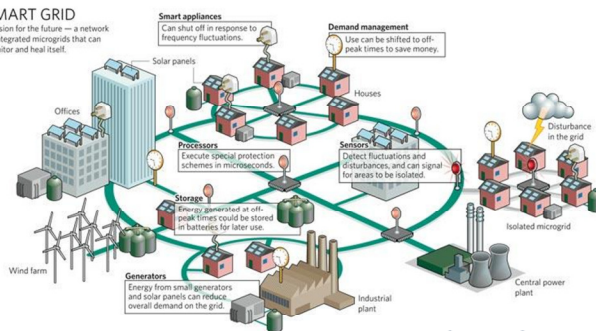


# An Introduction - Smart Grid 101

## Chapter 5: Rate Design



**SMART GRID**  
A vision for the future — a network of integrated microgrids that can monitor and heal itself.



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**Electricity Markets and Policy Group**  
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**March 2011**

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6/16/2011

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The Smart Grid is a compilation of concepts, technologies, and operating practices intended to bring the electric grid into the 21<sup>st</sup> century. Smart Grid concepts and issues are difficult to address because they include every aspect of electric generation, distribution, and use.

While the scope of smart grid covers the entire utility system from generation to how customers use energy, the three chapters in this portion of the tutorial primarily focus on the intersection between the distribution grid and customer. All elements of smart grid include important engineering, economic, and policy issues. However, with the exception of alternative generation options, the generation and transmission segments are less uncertain and more dominated by engineering economics than the distribution and customer segments.

This Smart Grid 101 tutorial is divided into chapters that address significant individual technical and policy areas. Each chapter attempts to isolate and define technical and policy issues relevant to state regulators. Our objective is to more clearly define the components of Smart Grid, identify how these components interact, and then present information to clarify policy and decision options.

Smart Grid is often considered confusing because it covers not only the entire electric infrastructure but also new technologies, customer interaction, legal, and regulatory issues. To address this problem, each chapter addresses a limited scope of issues derived principally from meetings with regulators, industry literature, and project team professional judgment.

This set of chapters address metering, rate design, and demand response.

## 5.0 Rate Design

### Objective:

**Describe the relationship between rates, prices and smart grid, identify the policy issues, and identify potential implementation options.**

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Dynamic pricing is a key benefit for many utilities in their business case for Smart Grid/AMI deployment. Many of the benefits, particularly on the customer side of the meter, are driven by rate design.

The objective of this chapter is to describe the relationship between rate designs, the prices they communicate, and their role as primary drivers of smart grid benefits. In addition, this chapter will identify potential implementation strategies to address or mitigate potential adverse impacts from dynamic rates and a transition to a smart grid environment. Finally, key rate related policy issues will be identified and discussed.

## 5.01 Rate Design



### Discussion Topics

Topic	Slides
5.10 Rate Design Markets and Products	5.10 – 5.19
5.20 Experience To-Date	5.20 – 5.25
5.30 Transition Planning	5.30 – 5.34
5.40 Rate Design Issues	5.40 – 5.47
5.50 References	5.50

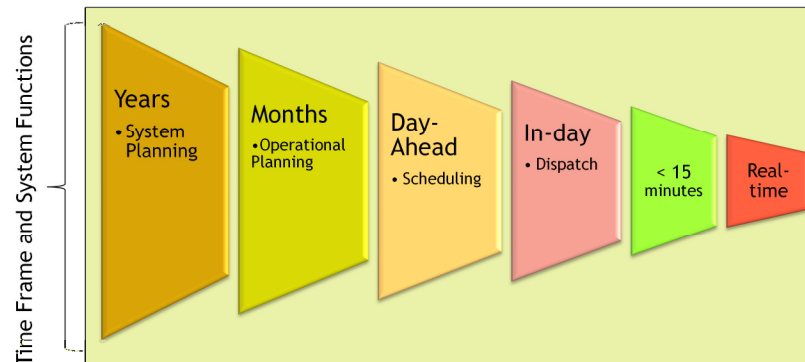
This Rate Design chapter is divided into five principal sections, concluding with a list of follow-up references.

## 5.10 Rate Design



### Market Context: Regulated Monopoly

Under the vertically integrated model, engineering, economic planning, system operations are closely linked over time.



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Vertically integrated and regulated electric utility markets differ substantially from markets with retail competition and organized wholesale markets. However, different market structures and designs need to address similar supply-demand and rate design elements

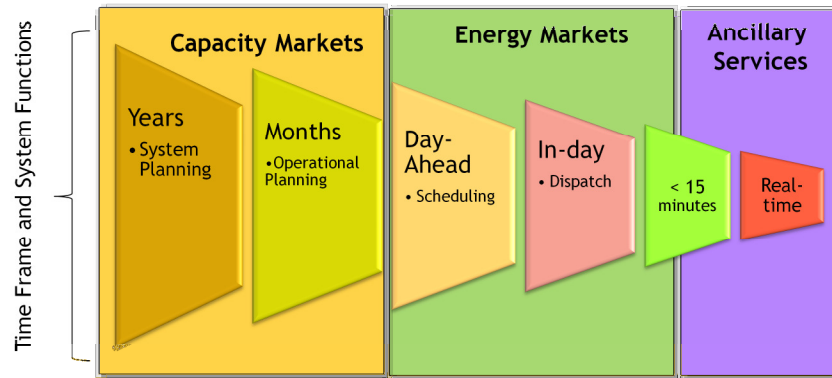
This graphic is intended to represent the various components of resource planning and system operations that influence provision of electric services provided in a vertically integrated regulated market. Electric utilities have to provide capability for and integrate a variety of supply options to provide reliability and follow demand at all times. In a vertically integrated regulated system the resources to track demand are addressed through resource planning and operations. Utilities produce long-term plans that look out 20-30 years and are also responsible for scheduling generating resources (typically a day-ahead) and operating their systems in real-time to meet reliability requirements. The resource planning process examines and selects a portfolio of supply-side and demand side resources based on projected load forecasts over a ~15-20 year time horizon that meets system reliability needs and considers capital and operating costs and various risks.

## 5.11 Rate Design



### Market Context: Competitive Markets

Markets perform the same functions through a series of markets which operate over different time horizons, creating new product opportunities for retail customers and new opportunities for efficiency gains.



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In competitive wholesale and retail markets, various entities (generators, ISO, distribution utilities, retail suppliers) perform these same functions as a vertically integrated utility would in a region without organized markets. However, in electricity markets with wholesale and retail competition, markets are designed and created to provide various system functions and administered by new entities (e.g. regional transmission organizations or independent system operators) that previously were performed by vertically integrated utilities as part of the provision of electric services. Each of these separate markets perform over different time horizons, which in turn create different opportunities for efficiency gains and new product opportunities for retail customers. Each of these markets and time horizons determine potential rate design options.

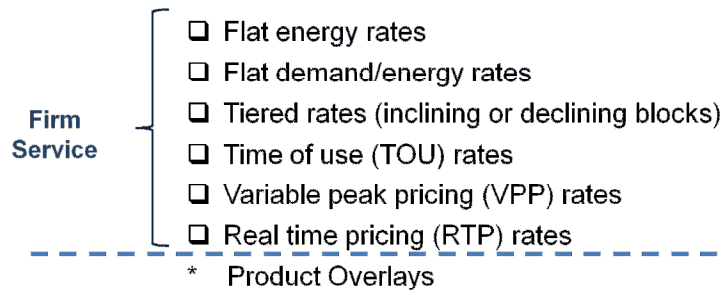
The critical messages from this and the previous slide:

- While there are substantial differences between regulated and competitive markets, the system components necessary to supply electric service are similar for each, and
- The time dimension that differentiates each of the system components is a critical factor in defining rate designs compatible with Smart Grid.

## 5.12 Rate Design



### Defining Dynamic Pricing Six Basic Structures for Firm or Default Service



\*Most rate structures also include a customer or access charge.

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There is a taxonomy of products and rate design options relevant to Smart Grid with application to both the retail and wholesale markets. This discussion of rate design focuses on the traditional retail view of rate design because it is most relevant to state regulatory domains.

There are three basic categories of rate design, where each is differentiated by how often they change and send different price signals: (1) flat rates and tiered rates, which are identified by the first three examples, (2) time varying rates which are characterized by the last three examples, and (3) and product overlays which will be discussed on a later slide.

This slide identifies six common default or firm service rate structures that populate the first two categories.

These rate forms and product overlays are the basic building blocks for a wide variety of rate designs.

## 5.13 Rate Design



### Time-Varying Rate Structures (typical designs)

- ❑ **Time of Use**
  - Prices for peak, shoulder and off-peak periods established a year in advance
- ❑ **Variable Peak Pricing (VPP)\***
  - A hybrid of TOU and RTP
  - The on-peak period (hours and seasons) is defined in advance
  - Peak period prices for the next day are established based on the day-ahead forecast of wholesale market prices
- ❑ **Real-time Pricing (RTP)**
  - Hourly prices change based on system or market conditions on a day-ahead, hour-ahead or real-time basis

\*There is also a product overlay known as variable peak pricing which is a variant of critical peak pricing.

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Time varying or time-of-use (TOU) rates may have two to three different rating periods. They can also be differentiated seasonally. Time periods and the prices in each rate period are usually defined a year in advance.

Variable Peak Pricing (VPP) is a hybrid of time use and real-time pricing, where the rating periods are defined in advance but the prices are updated on a forecast basis. For example, in VPP, the on-peak price may be set equal to the average day-ahead wholesale market price for the on-peak hours. The on-peak prices could also vary hour-by-hour based on the same wholesale market prices or some index designed to reflect system marginal costs. All other VPP rating periods would be fixed, similar to TOU rates.

VPP rates are much more dynamic than TOU rates but less complicated than RTP.

For real-time retail pricing (RTP) tariffs, in an organized market, energy prices are typically linked to day-ahead or real-time energy markets and change hourly (or more frequently – e.g. every 30 minutes). In markets with vertically-integrated utilities that operate in regions without organized markets, real-time prices are typically set by the utilities administratively based results from production cost models that reflect system conditions and estimate short-run marginal costs. PUCs have established Real-time pricing tariffs as the default service for large industrial and commercial customers in 5-6 states with retail competition (e.g. NY, NJ, PA, MD, IL). About ~70 utilities offer voluntary RTP tariffs on an opt-in basis primarily targeted to large industrial/commercial customers; the most successful RTP tariffs in terms of customer enrollment are Southern Company, Duke, TVA. Commonwealth Edison has a day-ahead RTP tariff that targets residential customers and has achieved significant customer enrollment.

## 5.14 Rate Design



### Dynamic Pricing: Product Overlays

- ❑ A product overlay can simply be layered on top of the existing firm rate under specified conditions, with no (or minimal) adjustments to the underlying basic firm rate.
- ❑ Examples:
  - Interruptible/curtailable (I/C) rates
  - Direct load control (DLC)
  - Critical peak pricing (CPP)
  - Peak time rebate (PTR)
  - 2-part real time pricing (2-Part RTP)

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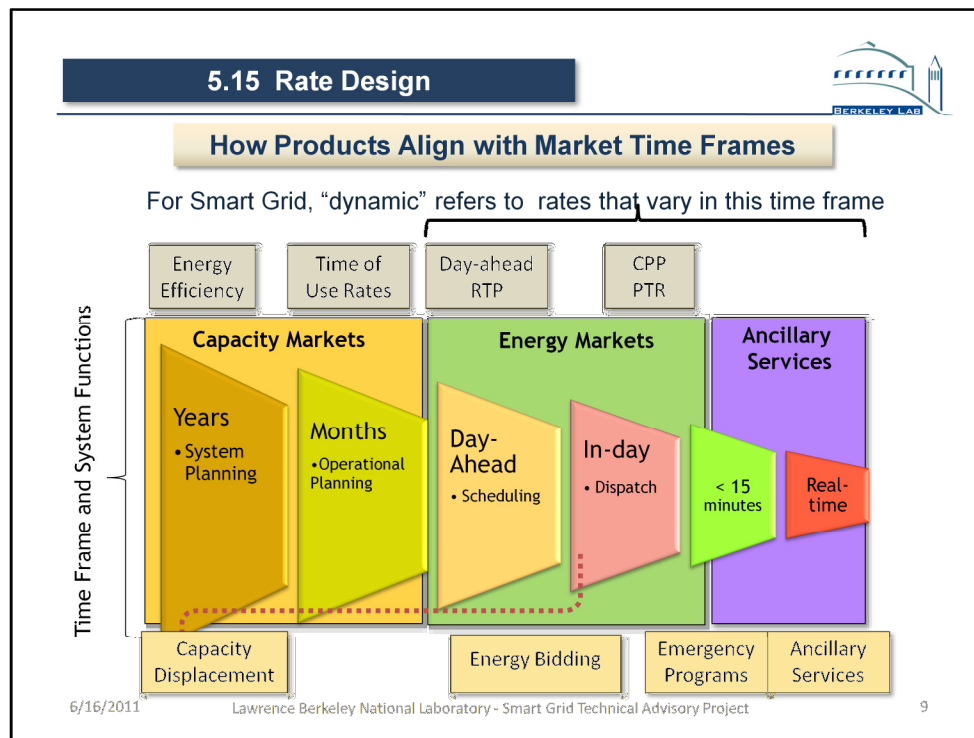
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Product overlays describe rates that apply a modifying condition to an existing rate. Product overlays generally apply under limited or specific system conditions with limited adjustments to the basic firm rate.

Five examples of product overlays are listed, although only the last three deal with rate or pricing options. All of these options with the exception of PTR have been around for decades.

With regard to the three pricing options, CPP and PTR can and have been offered as overlays on flat rates, tiered rates, and TOU rates.





A key dimension for each of the rate forms identified in the prior slides is the time dimension and frequency over which price changes are implemented. In the context of Smart Grid, dynamic rates or smart rates refer to prices that vary in the same day or real-time time frame.

One of the major benefits of Smart Grid is attributed to the optimization of the distribution system and the ability to allow participation by customer loads (e.g., dynamic pricing, more demand response options) to help in real-time balancing of supply and demand. TOU and other static rates, where prices are set in advance and not reflective of day-to-day or hourly system conditions, can't support and respond to system operational needs that occur within day. For example, electric vehicles will require near real-time price signals to regulate charging start and end times and to modulate the rate of charge. Flat and tiered rates don't address this need. TOU rates potentially address the charging time cycle but don't provide information necessary to address charge rate modulation. Other issues with CPP and PTR are raised in the next slide.

Each of the various rate forms identified earlier are aligned along the top of this graphic, matched with the market components and relevant time dimension. In this example, RTP, Critical Peak Pricing (CPP), and Peak Time Rebate (PTR) are the major rate forms consistent with the time dimension pricing requirements claimed by proponents that claim Smart Grid will enable certain types of system benefits (e.g., use of customer loads to provide certain ancillary services, large-scale integration of variable generation).

## 5.16 Rate Design



### Dynamic Pricing Overlays: CPP vs. PTR

Design Feature	Critical Peak Pricing	Peak Time Rebate
Resource goal	Peak load reductions	Same
Critical Peak Period Definitions	Typically defined in advance	Same
Event Price	Typically defined in advance	Same
Revenue Neutrality (relative to base case)	Firm rate + CPP rate designed to be revenue neutral <ul style="list-style-type: none"> <li>Can create windfall gains &amp; losses</li> <li>May need revenue adjustments if all events are not called in order to recover required revenue</li> </ul>	PTR not designed to be revenue neutral (requires initial rate increase to cover rebates) <ul style="list-style-type: none"> <li>Can create windfall gains due to how the CBL is defined</li> <li>Can be called only as needed</li> </ul>
Customer-specific baseline load (CBL)	Not required	Required – a major implementation issue

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One of the observations from pricing pilots conducted over the last 10 years is that product overlays like Critical Peak Pricing (CPP) and Peak Time Rebates (PTR) have surfaced as two of the most feasible options to facilitate dynamic pricing for residential customers. This table compares several of the key features for each of these rate options.

From a design point-of-view both rates are very similar. Both products focus on peak load reduction and in almost all instances the critical peak periods and event prices are fixed and defined in advance. In many implementations both CPP and PTR are either implemented or can be implemented on similar TOU base rates.

CPP and PTR have three fundamental differences.

- 1) CPP is designed to be revenue neutral. PTR is not revenue neutral in that rates have to be increased to fund the rebates or credits.
- 2) Under CPP customer benefits come from avoiding critical peak costs. CPP is often referred to as a "Play or Pay" rate. If the customer does nothing in response to high prices they will pay the higher rate for each kilowatt hour they use. Under PTR, customer benefits come from utility payments or bill credits, often applied separate from the monthly bill, that reflect utility avoided costs. PTR is often referred to as a "No Loser Rate" because if the customer does nothing in response to the peak time event, their bill is not affected.
- 3) CPP charges are based on actual metered usage. PTR credits require a 'baseline' computation that attempts to estimate for a peak day how much energy each customer would have used in the absence of the event which is then compared with how much they actually used. Baseline computations are typically based on an average of prior-day(s) usage during the same or preceding billing month. Several studies have been done comparing as many as ten or more baseline methodologies. Baseline methods work best for customers that have consistent and relatively predictable usage patterns and schedules; they are more problematic and challenging for customers that have highly variable and unpredictable schedules, operating practices, etc. The inherent problem with baselines is the difficulty in measuring what would have otherwise occurred without the peak time event. In addition, baseline computations require a certain number of similar (weather, day-type, non-holiday, etc.) non-critical, uncontrolled days in the same or preceding billing period, which may or may not be available.

## 5.17 Rate Design



### Dynamic Pricing Overlays: Two-Part RTP

- ❑ Part 1 – Customer baseline load (CBL):
  - Retains the price hedge embedded in the customer's basic service rate
  - Requires setting a CBL, typically defined by the historical hourly load profile
- ❑ Part 2 – Hourly marginal cost:
  - Changes in usage from the CBL would be priced at utility's marginal cost (or market price)

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Plain vanilla RTP simply charges the hourly energy price.

Two-part RTP is the third “product overlay” identified on Slide 5.14. Two-part RTP rates were developed in the late 1980's to address a changing relationship between utility embedded and marginal costs created by a period of high investment in nuclear and other resources. Due to a compressed period of major investment, embedded costs substantially exceeded marginal energy costs. Under these circumstances, customers would prefer a standard RTP rate option based only on marginal cost, however the result would be a substantial under collection of the utility revenue requirement.

Two-part RTP rates were designed to provide a way to recapture embedded costs. A customer baseline load was computed that reflects the customer historic hourly load profile or a base year. The customer pays one rate for the baseline load based on embedded cost. All energy used in excess of the baseline would be charged at the short-run marginal cost.

## 5.18 Rate Design



### Are “Smart Rates” Necessary to Achieve Benefits of Smart Grid

- ☐ Yes, especially to achieve the potential benefits for consumers:
  - Rate structures provide price signals.
  - Price signals link the utility system and customer.
  - Price establishes the customer value function.
  - Price enables the benefits of smart grid to be achieved.
- ☐ Rate design for regulated service is the domain of state regulatory commissions - it is not being addressed by NIST\*.

\*NIST = National Institute of Standards and Technology

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In the context of this chapter, “Smart Rates” are also known as dynamic rates.

Are “Smart Rates” necessary to achieve the benefits of Smart Grid? The answer is YES.

Dynamic rates provide price signals that customers can use to determine if they want to adjust their usage pattern given the actual costs of providing electricity. Price signals in conjunction with automated controls and smart appliances can provide a “fast response” necessary to address the time dimension necessary to support demand response ancillary service options and controls necessary to address electric vehicle and intermittent resource applications.

Dynamic rates to some degree require significant price differentials that create distinct peak and off-peak periods. Price differentials create the economic value function to justify customer investment in automation or in alternative on-site generation resources.

Flat rates provide a signal that there is no hourly difference in either the cost or value of energy and that it's ok to use energy at any time during the day. Obviously, this is not the right signal to send if your utility has distinct cost differentials, periods of congestion, or problematic peak loading problems.

Finally, price signals together with energy usage patterns have an accumulative effect over time which creates the customer value function. The cumulative cost of energy over time establishes not only the value but the priority a customer may assign to their investments in behavior change or infrastructure improvements to reduce energy usage.

## 5.19 Rate Design



### **“Smart Pricing” Ideal Features to Support a Smart Grid Perspective**

- ❑ **Provide meaningful customer information**
  - Easy to understand use-cost relationship
  - Signals customers can and are willing to respond to
- ❑ **Digital price signals that can be:**
  - Communicated or broadcast electronically
  - Acted upon by customer controls, smart appliances, and energy management systems
- ❑ **Prices that integrate efficiency, demand response, distributed generation alternatives, and renewables.**

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Smart Grid is fundamentally a system integration effort, where rates and incentives are the basis for signaling and facilitating the integrated deployment of energy efficiency, demand response, and renewable energy projects. Separate rates and incentives designed to support individual distinct program options may unnecessarily segment the customer market and hamper integration at both the system and customer level and are inconsistent with the Smart Grid system integration vision.

Smart Grid is also assumed to be supported by sensors, measurement, and automated functions that can respond quickly to changing system conditions. Automating Smart Grid will require Smart Rate designs that provide capability to support two key functions.

1. **Dynamic Pricing:** Rates must be designed to reflect the time-varying dynamic nature of system costs. This generally means that some part of the rate must be dispatchable to reflect day-ahead, day-of, or real-time changes in system costs.
2. **Digital Price Signals:** Rates must be structured to provide digital price signals that can be communicated or broadcast electronically and directly acted upon by automated customer controls, smart appliances, and energy management systems.

## 5.20 Rate Design



### What do we know about Dynamic Rate impacts?

#### Load Impacts

- ❑ **Residential customers *in aggregate* respond to price**
  - Response varies due to rate designs, weather, class, etc.
  - Individually, some customers respond very little; others are much more responsive.
  - Large users provide larger load reductions.
  - Automation increases response and improves customer satisfaction.

#### Bill Impacts

- ❑ **Bill impacts depend on differences between**
  - Existing and new rate structures
  - Customer load profiles

#### Acceptance

- ❑ **Most residential customers that experience dynamic rates are generally satisfied with the experience.**

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### What do we know regarding dynamic rate impacts?

The first tests of dynamic rates began in the early 1980's with TransText pilots in AEP and Georgia Power. Since then there have been multiple pilots with varying experimental designs, technology applications, different levels and forms of incentives, and even more marketing and customer education options. Slide 5.21 highlights 60-70 different treatments from about a dozen of the most recent utility pricing pilots. While the variations among the pilots make it difficult to make exact comparisons or to transfer specific conclusions, there are several relative conclusions that seem to remain consistent across the vast majority of pilots.

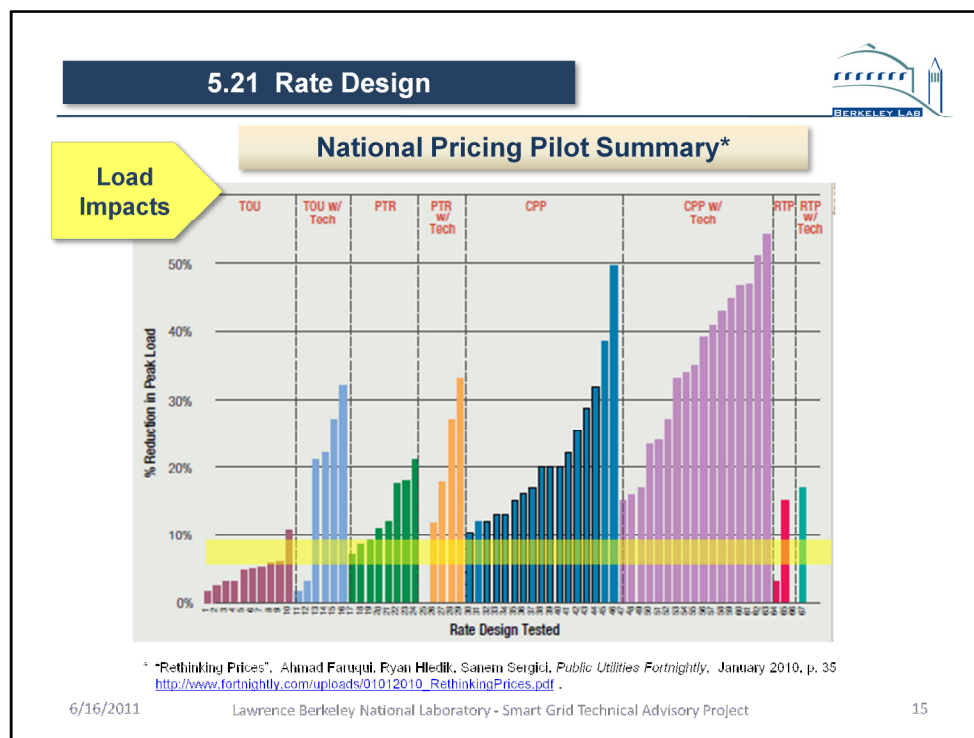
#### Load Impacts:

Regardless of the differences in rate design, customers that participate in these pilots in aggregate have responded to price signals. This holds true regardless of customer demographics, weather conditions, annual energy usage levels, or appliance holdings. Customers with higher usage provide greater impacts, however even low use, low income, and seniors on average reduce peak load in response to price signals. There are several other consistent observations with regard to load impacts, specifically:

- Automated controls substantially increase peak demand reductions and make those reductions more predictable and sustainable from year-to-year
- Price response, where the customer controls their own load response, tends to provide greater demand reductions than utility direct control.

Bill Impacts: Bill impacts are very dependent upon the differences between the base rate and dynamic rate and the distribution of customer bills as well as the presence or absence of low income and other subsidies. Most pilots tend to report more decreasing bills than increasing bills.

Customer Acceptance: Market research preceding pilots tends to find customers skeptical of dynamic rates, with the primary concern being the potential volatility in expected prices and bills. Market research following customer participation most often finds that a significant majority of customer prefer dynamic rates to their prior base or default rate. This result has significant implications for implementation and customer education, which is covered in the "Transition" slides later in this chapter.



This bar chart from a recent report by Brattle illustrates the wide range of reported peak load impacts from 18 pilots conducted starting in the late 1990's. The variation in impacts in this chart comes from the broad range of pilots and treatments being compared, which include CPP, PTR, and TOU combinations together with a variety of automation and in-home display options.

One of the initial impressions people often draw from this graph is that the variations are so wide as to render pilot results less than useful. With variations this diverse it creates uncertainty regarding what any individual utility might expect from their own potential implementation.

There is an alternative way to interpret this graph by looking both at the relative and literal results in combination. Superimposed in parallel to the X-axis is a yellow band that covers the 5-8% load impact level represented on the Y-axis. From a system wide perspective, 5-8% may be all that is necessary mitigate seasonal peak load system reliability issues. From a system perspective, the objective of demand response is not necessarily to obtain the maximum demand reduction from each customer but to make sure you can obtain an aggregate reduction from the responding customer necessary to mitigate adverse peak conditions.

One of the short comings of almost all pilots conducted to-date is that none have attempted to determine what the optimum peak load reduction or customer participation rate should be. Higher peak demand reductions may require more stringent control strategies, potentially higher customer participation levels, or greater peak to off-peak price differentials.

Higher customer participation levels will materially impact whether pricing is structured as opt-in or an opt-out option. This decision becomes even more important if pricing is being targeted to manage transmission or distribution congestion, where higher saturations of customers will be required. Congestion management may also require substantially higher average load reductions than the 5-8% noted previously.

Customer participation levels will also impact the control strategy. Lower participation rates (often associated with opt-in approaches) may and more stringent control strategies increase the challenge to customer acceptance and retention. Higher participation rates (associated with opt-out approaches) will require less severe control strategies which will more positively impact customer acceptance and retention.

Considering these additional perspectives, the Brattle graph offers additional interpretations and questions:

- The vast majority of pilots depicted in this graph, specifically those with CPP and automation technology, reflect load impacts that far exceed what might be necessary to mitigate system peak loads. Do these results reduce the perceptions of risk in regulatory or utility decisions to pursue or not pursue dynamic pricing options?
- What level of load impact and customer participation is necessary to support locational applications of DR for transmission and distribution congestion management?
- What is the price threshold necessary to achieve the required peak load impacts for any DR application?
- While opt-in and opt-out approaches to pricing both preserve customer choice, how do you rationalize the perceived differences when only opt-out will provide customer participation levels necessary to support potentially valuable transmission and distribution congestion management applications?

The level of peak load impacts any utility will require will vary based on whether the objective is to address generation reliability versus distribution or transmission congestion issues. It may also be the case that answers to the questions above cannot be determined from pilots but are dependent instead on more iterative operating practices.

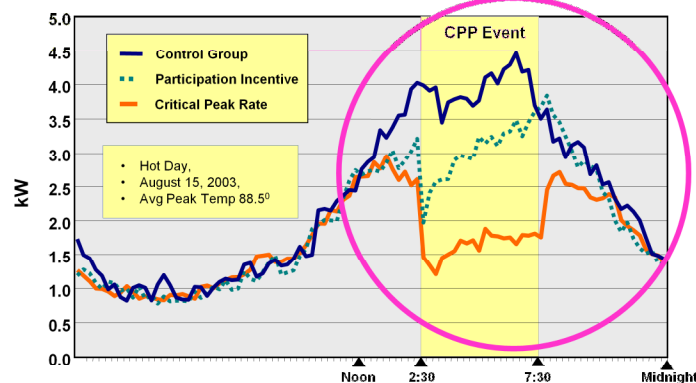
## 5.22 Rate Design



### Load Impacts

### California Statewide Pricing Pilot

#### Residential Response with Automation: Participation Incentive vs. Critical Peak Rate\*



\*Advance Metering and Statewide Pilot Project, Results and Issues; Joint Workshop of the Resources Agency, CEC, and CPUC, September 30, 2004.

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This example was provided to compare and illustrate one example of conventional utility direct control with price response. The above graph came from the 2003-2004 California Statewide Peak Load Reduction pilots (SPP), more specifically from a set of residential cells in the San Diego Gas and Electric Company (SDGE) territory. SDGE implemented a 5,000 point programmable controllable thermostat pilot\* the year prior to the SPP where they managed and controlled a utility installed programmable communicating thermostat (PCT). During peak control periods SDGE remotely controlled customer thermostat settings, by remotely raising the temperature by 4 degrees during critical peak periods, for which customers were paid a flat \$100 participation incentive each season. For the SPP, several hundred customers who had already participated in the SDGE controlled pilot for at least one year were randomly recruited out of the pool of 5,000. Each of these customers was placed on a CPP rate, their seasonal fixed incentive was eliminated, and they were told their incentive levels would now depend on how they responded to CPP price signals.

This graph compares the average hourly loads (daily load shape) for a 2003 peak summer day, contrasting a control group, the customers remaining on the 5,000 point direct control PCT pilot, and the SPP CPP participants. This graph is for the summer peak day in 2003, and while it does not represent the average impacts over all critical peak days, it does illustrate some basic response differences between utility direct control and customer price response.

What is evident from this graph is that the CPP participants (orange line) significantly reduced their load more than those on direct control (green line). One explanation is that direct control is focused exclusively on the 'appliance' targeted in the program, in this case the HVAC unit, while CPP automatically includes all premise loads, which gives the customer more options to reduce load and optimize their incentives. In this part of the SPP pilot, the customers moved from direct control and fixed participation incentives to CPP on average doubled their load reduction and substantially increased their incentives.

•[http://www.smartgridinformation.info/pdf/2406\\_doc\\_1.pdf](http://www.smartgridinformation.info/pdf/2406_doc_1.pdf)



## 5.23 Rate Design

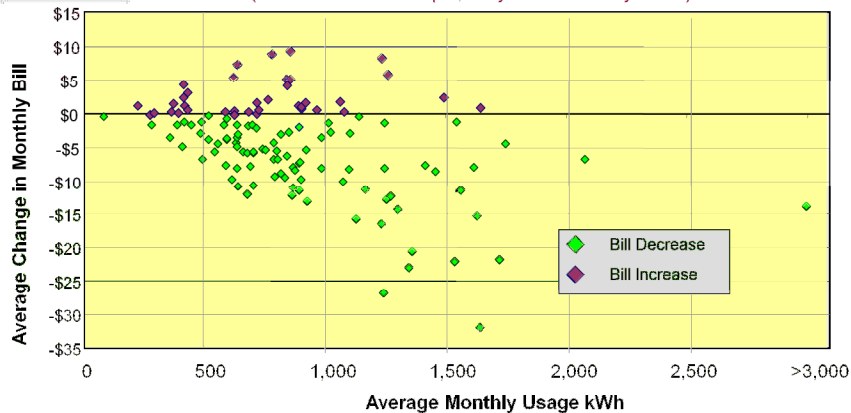


### Bill Impacts

### California Statewide Pricing Pilot \*

#### Actual Distribution of Residential Bill Impacts

( SDGE CPP-V Example, July 2003 thru May 2004 )



\* Source: CEC analysis of SPP billing data, August 2004 (SDG&E).

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This graphic illustrates the distribution of residential bill impacts from participants on the SPP CPP rate, also in SDGE. Approximately 20-30% of the customers experienced bill increases, while the remaining 70-80% experienced bill decreases. During the SPP no effort was made to provide mitigating education or other efforts to target or assist customers whose bills increased.

## 5.24 Rate Design



### Bill Impacts

### SMUD Small Commercial Solutions Pilot \*

Business Type	Program Option	kWh Savings (% 2007 baseline)	DR Impact (% 2008 baseline)	Monthly Bill Savings		
				EE	DR	Total
Office	4° ACC	-27%	-38%	\$ 29	\$ 10	\$ 39
	CPP	-32%	-24%	\$ 39	\$ 7	\$ 46
Retail	4° ACC	-15%	-22%	\$ 29	\$ 10	\$ 39
	CPP	-19%	-14%	\$ 39	\$ 7	\$ 46
Restaurant	4° ACC	-8%	-1%	\$ 29	\$ 10	\$ 39
	CPP	-10%	-3%	\$ 39	\$ 26	\$ 65
All Participant Average		-20%	-20%	\$ 36	\$ 10	\$ 46

\* Source: SMUD 2008 Small Business Summer Solutions Pilot

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This is another example provided to illustrate bill impacts for customers on a CPP rate. This example comes from an innovative small commercial pilot conducted by the Sacramento Municipal Utility District (SMUD) in 2008. This pilot integrated SMUD's small commercial energy audit program with a CPP rate employing PCT controls activated by SMUD dispatched price signals. Customers were offered energy audits and a PCT if they would agree to participate in the CPP pilot. Customers determined how and whether to respond to price signals. The PCT's provided traditional load shedding and pre-cooling options.

The kWh and peak demand kW savings numbers are represented in 'red'. kWh savings are based on a full year of data, while the peak load kW savings are for the summer peak months.

The average bill impacts for all customers in the pilot are highlighted in the oval on the far right. Like the SDGE bill impacts on the previous slide, some customers experienced small bill increases, however more customers experienced bill decreases as the averages reflect.

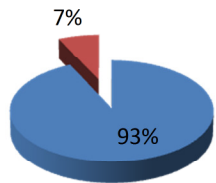
## 5.25 Rate Design



### Acceptance

### PowerCents DC Program Results

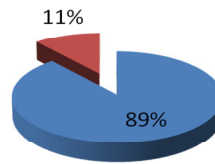
Which price plan did you prefer?



■ PowerCentsDC Plan  
■ Former Pricing Plan

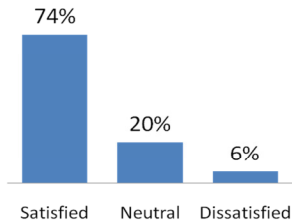
\* July 1, 2010 White House Briefing

Would you recommend PowerCentsDC electricity pricing to your friends and family?



■ Yes ■ No

Overall, were you satisfied, neutral, or dissatisfied with the PowerCentsDC program?



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This final example was pulled from the recent Washington DC PEPCO PowerCents pilot. It is included here only to illustrate the very strong customer acceptance being reported from dynamic pricing pilots. Results from several recent pilots have reported similar results.

## 5.30 Rate Design



### Transitioning to a Smart Grid What are the Issues?

- 1 How do we transition customers from existing flat and tiered rates to a dynamic rate?
- 2 How do we inform and educate customers regarding both the opportunities and risks?
- 3 Will technologies be available so customers can automate their response?
- 4 What can we do to identify and mitigate potential adverse bill impacts before they create problems?

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On a conceptual level regulators and consumer advocates can often agree that dynamic rates could provide customers with greater choice for managing their energy costs and more importantly, provide a critical tool for achieving Smart Grid benefits. There is also a 15+ year history of dynamic pricing pilots that seem to indicate that many residential customers will respond, that many will experience positive bill impacts, and that the majority will come away with a positive experience.

What regulators and consumer advocates don't often agree on is how to implement dynamic rates, especially how to address, limit, and mitigate some of the potential adverse impacts.

The recent backlash to smart meters reflected in Internet blogs, newspaper articles, and regulatory proceedings indicates that there are still many dynamic rate implementation uncertainties that need to be addressed.

We've identified four key issues that bracket the implementation issues.

1. How do we transition customers from existing flat and tiered rates to a dynamic rate?
2. How do we educate and inform customers regarding both the opportunities and risks?
3. Will technologies be available so customers can automate their response?
4. What can we do to identify and mitigate potential adverse bill impacts before they create a problem?

Collectively we view the answers to these four questions as the basis for developing a practical implementation plan. However, given the complexity of these issues, utilities and regulatory agencies may want to consider a transition plan in which dynamic rates, enabling technology, and customer information systems, information and behavior issues are addressed over a multi-year period.

## 5.31 Rate Design



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### How do we transition customers from existing flat and tiered rates to a dynamic rate?

#### □ Time Frame Issues:

- Education: [Virtual Participation] familiarize customers with rate structure and prices before rate introduction – minimum 6-12 months.
- Education: need to provide continuing information on adaptation methods and technologies – ongoing.
- Technologies: 3-5 year minimum acquisition cycle for low cost adaptation options
- Technologies: 4-9 year minimum acquisition cycle for major appliance and infrastructure options

#### □ Rate Design considerations / options

- Transition from “safe” PTR to dynamic CPP.
- Phase in dynamic rate price differentials over a 3-5 year period.
- Opt-out options to hedged flat or TOU rate.

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The conventional approach for implementing new rate designs generally allows for a limited period of advance notice, may include bill stuffers that provide customers with information sheets, and in rare circumstances supplemental marketing or education material followed by a ‘date certain’ rollover from the old to new rate. In most cases, new rates just reflect minor changes in seasons, tiers, rating periods, or prices.

Dynamic rates are more complicated because they often present new rate structures and pricing that is designed to influence customer usage patterns and customer appliance purchases. Automation technology impacts customer adaptation and it is often considered an integral partner to a dynamic rate, however automation technology may not be readily available and even if it is, installation often takes time.

The requirements for implementing dynamic rates logically argue for a transition period that allows more time to provide customer education and acquire the technologies necessary to automate customer response. Rate complexity associated with dynamic rates also argues for simpler rate designs, tools, and educational material that personalizes potential impacts.

## 5.32 Rate Design



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### How do we educate customers regarding both the opportunities and risks?

- ❑ **Pre-Rate Introduction - Shadow Bills [Virtual Participation]**
  - Provides customers with side-by-side comparison of potential bill impacts
  - Can be supplemented with adaptation and technology information to address opportunities and mitigation
- ❑ **Post-Rate Introduction (ongoing)**
  - Web-based tools and information
  - Case studies to illustrate adaptation
  - Technology reviews, case studies, incentives
  - Shadow bills, cumulative accruing impacts to provide post implementation (purchase) confirmation

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In many pricing pilots, customer education has often been deliberately curtailed or limited to reduce bias and adverse influence on participants. As a result, there are no “best practices” or silver bullets that can be used to guide future implementation.

Pilots have demonstrated that once customers become familiar with how a dynamic rate actually impacts their bill – adaptation improves and perceptions of risk decline.

Bill guarantee options have been used to provide customers experience on a dynamic rate while simultaneously reducing their financial risks. These options guarantee that a customer, during the first year, will pay no more on the new dynamic rate than on their old rate. While the bill guarantee credit at the end of the year makes the customer ‘whole’, customers had to front the money to pay their bills and those that paid more, were almost certain to discontinue participation.

Shadow bills offer another option with substantially less risk to the customer. Shadow bills allow the customer to see exactly how the dynamic rate will impact their bill, without creating a cash flow issue. Shadow bills also allow both the utility and regulator to identify each customer that might experience adverse bill impacts and to develop and explicitly target those customers for mitigation measures, which may include other energy efficiency options, energy audits, or even opt-out recommendations to more conventional rate options. Shadow bills also simplify the utility implementation by eliminating the bill accounting and rebate activities with guarantee alternatives.

It is important to note that customer education should also address post-implementation efforts, where shadow bills may continue to play an important role in what is known as ‘post purchase satisfaction’ reinforcement. Reinforcing what customers see in ongoing savings over their old rate can help confirm the customer decision (to not opt-out or to opt-in) and could motivate continuing positive usage changes.

### 5.33 Rate Design



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#### Will technologies be available so customers can automate their response?

- ☐ **Utility provided programs**
  - Can be implemented in 1-2 years
  - Limits technology options, customer choice, cost
  - May require subsidies, incentives on top of rate
- ☐ **Non-utility competitive market options**
  - Will require 3-5 years to seed the market
  - Will encourage multiple technology, service, cost, and customer choice options
  - May require subsidies or incentives to facilitate implementation and accelerate customer purchase

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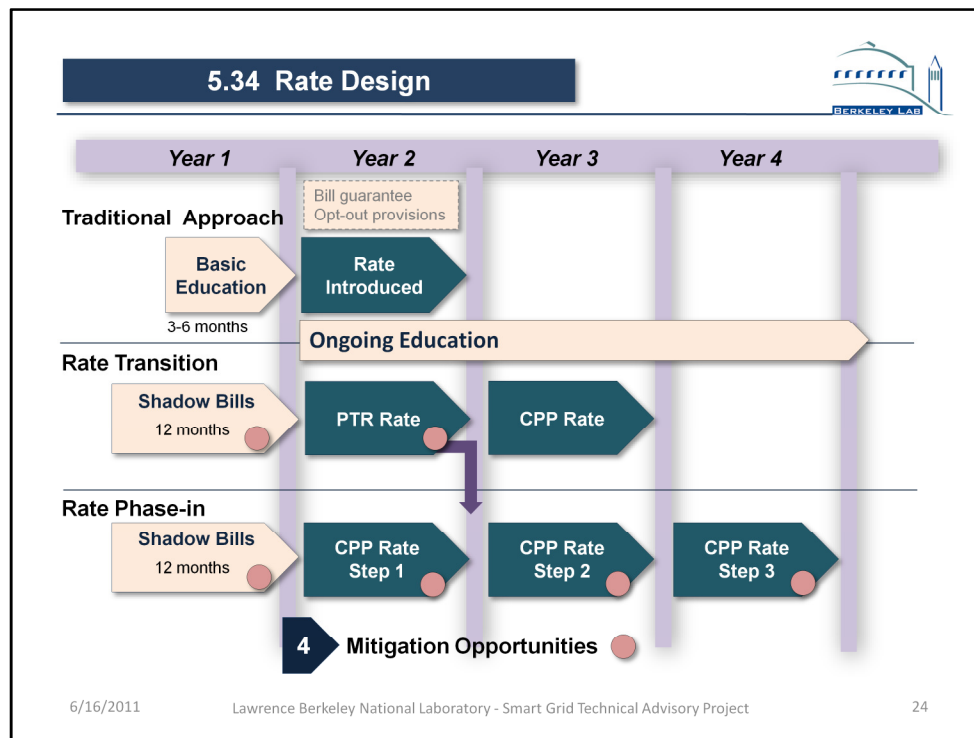
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There are two potential options for providing customers with price responsive automation technology and two basic options for guiding rate implementation.

	Rate Implementation Options	
Technology Options	Opt-out	Opt-in
Utility Program	1-2 years	3-5 years
Open Market	3-5 years	3-5 years

**Technology Options:** There are two fundamental options to guide customer technology implementation. (a) Under a utility program the utility provides the rate, incentives, control technologies and manages/oversee implementation or (b) under an open market approach, the utility provides the rate and possibly the incentive/subsidies, however competitive retail vendors provide customers with technology, service, and implementation options. Utility programs provide uniform technology options often designed with utility specific features, little ability to address individual customer needs, and usually focus only on 1-2 suppliers. Any utility specific features, combined with limited volume purchases and few suppliers can result in higher costs. If there are sufficient number of vendors, open market programs may spur innovation, products and services specific to customer needs, cost competition, and provide numerous channels for education and mitigation.

**Rate Implementation:** Opt-out programs (aka default enrollment) can proceed reasonably quickly under either a utility technology option, however all other rate implementation options will require reasonable periods of time to facilitate the implementation of automation options.



This graphic contrasts three potential dynamic pricing implementation options. The first option labeled 'Traditional Approach' has been the pattern followed by most utilities. Both of the other two options discussed here are proposals that could be considered by utilities and regulators.

The 'Traditional Approach' mirrors the standard regulatory practice described in the first paragraph of Slide 5.31, which provides a relatively brief period of education, may include rate guarantees, but provides limited capability to mitigate potential problems. Limited mitigation options tend to strongly favor voluntary opt-in arrangements.

The second option, labeled 'Rate Transition', includes shadow bills for a lengthy period in advance of any actual rate implementation. This option also propose using a Peak Time Rebate (PTR) as a transition step to a more dynamic rate. The argument for PTR is that as a 'no loser' rate, it carries no negative bill impacts which makes it a safe option. Unfortunately, there are concerns that : (1) PTR baselines are complex, which can confuse customers and this rate form does not really communicate the reward / penalty incentives in a true dynamic rate, and (2) PTR is not compatible with advanced or day-of demand response options capable of supporting ancillary services, which could misdirect customer automation investments.

The third option, labeled 'Rate Phase-in' includes shadow bills like option #2. Under a 'phase in' approach, the peak to off-peak ratios would be moderated and implemented in steps over a 3-5 year transition period. This approach has several potential benefits, specifically:

- Provides customers with the basic rate form early in the implementation but not the price differentials planned for the final rate.
- Provides both the utility and regulator with opportunities to moderate and monitor bill impacts and head off any problems that might occur with the full peak to off-peak price differentials
- Provides both the utility and regulator with opportunities to monitor demand response impacts and potentially identify interim price points that achieve the system goals, which may not require the fully anticipated peak to off-peak price differentials.



## 5.40 Rate Design



### Issues

1. **When to consider implementation**
2. **Rate Design as a tool to integrate EE, DR, and renewables.**
3. **What type of Rate Design: Basic Service or Product Overlay**
4. **Mandatory or Voluntary Participation**
5. **Low Income /Senior Bill Impacts**
6. **What don't we know**

This list of six rate design issues is not exhaustive, however it captures the most frequently raised concerns.

## 5.41 Rate Design



### Issue #1: When to Consider Implementation ?

- ❑ **Do nothing – let others resolve the uncertainties**
  - Wait for FERC to resolve design and DR incentives
  - Let the wholesale ISO/RTO define DR products for retail customers
  - Wait and observe the DOE-funded ARRA Smart Grid Investment Grant Consumer Behavior Studies
- ❑ **When to begin planning – Factors to consider:**
  - Do you have pending state mandates (renewable portfolio standards)?
  - Do your customers want to take advantage of smart appliances?
  - Do you anticipate a growing penetration of electric vehicles?
  - Earlier preparation and planning might mitigate potential problems and minimize lost opportunities

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Implementation has to consider practical and policy issues.

On the practical side, dynamic rates require a working system of advanced or smart meters, tested capability to transmit or communicate price signals, a functional back office utility billing system, and the availability of customer automation technology, customer support, and customer service options.

On the policy side, this slide outlines two basic options.

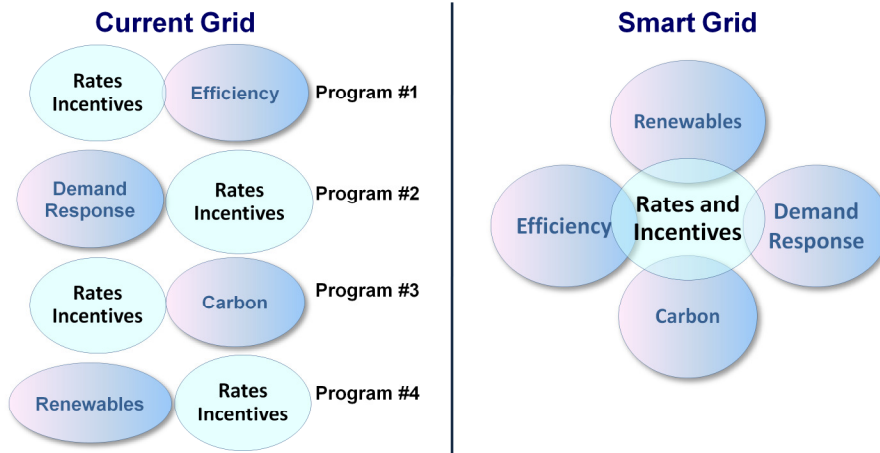
The 'Do nothing' or wait-and-see approach may be characterized by an approach that waits until other states, other utility pilots, or federal actions resolve outstanding critical issues. Waiting for results from the recently funded ARRA customer behavior pilots may yield valuable new information, however results from these pilots may not be available for 3-5 years.

The second approach requires utilities and regulators to assess the economic and system conditions in their jurisdictions. Implementing advanced or smart meters is generally guided by a business case that assumes price and/or demand response benefits. Delaying the implementation of a dynamic rate could jeopardize the cost-benefit foundation for that business case. Legislation or other mandates to achieve renewable or clean energy resource portfolio standards, electric vehicle objectives, and system congestion and reliability issues also can influence the need to consider dynamic rates.

## 5.42 Rate Design



### Issue #2: Rate Design as a tool Integrating EE, DR, and Renewables?



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Most utilities organize their efficiency, demand response, and renewable initiatives into programs that separately bundle customer participation rules, rates, incentives, customer education, and technology options into a single offering package. The graphic in this slide is intended to illustrate under the "Current Grid" how each initiative is bundled with its own rates and incentives.

Problems can occur when customer participation rules or rates and incentives designed for one initiative conflict with another. For example, inclining block tiered rates are often assumed to provide incentives for energy efficiency and conservation. Overlays can provide some capability to address demand response, however these rates are generally considered sub-optimal for large-scale deployment of electric vehicles, solar PV, and storage.

One option is to continue to provide separate rates and in some cases separate meters to accommodate this "program" approach to rate designs and incentives. Unfortunately, this approach can be confusing to the customer because it can provide perverse and contradictory incentives with regard to energy usage and resource allocation.

Rate simplification and designs that integrate the incentives for efficiency, demand response, and renewables can have positive impacts on the effectiveness of customer education and resource allocation initiatives.

## 5.43 Rate Design



### Issue #2: Rate Design as a tool Integrating EE, DR, and Renewables?

#### Rate Forms - Compatibility

Initiatives	Non-Dynamic Rates		Dynamic Rates		
	Tiered	Time of Use	Peak Time Rebate	Critical Peak Price	Real Time Price
Efficiency	No	No	No	Yes	Yes
DR (1) – Reliability, (Day Ahead )	No	No	Yes	Yes	Yes
DR (2) –Congestion Mgmt, Ancillary services (Day of)	No	No	No	Yes	Yes
Solar PV	No	Yes	No	Yes	Yes
Storage	No	Yes	No	Yes	Yes
PHEV / EV	No	Partial	No	Yes	Yes
Carbon Management	No	Partial	No	Yes	Yes

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### Integrating Rate Designs to Support EE, DR, and Renewable Initiatives

This table expands on the issue raised in the previous slide by looking at how specific rate forms match with the functional requirements for various efficiency, demand response, and renewable options.

Demand response options are divided into two separate initiatives to address unique rate design related timing and dispatchability characteristics that differentiate conventional day-ahead (DR-1) from day-of or real-time ancillary services (DR-2) applications .

Tiered and conventional time-of-use (TOU) rates provide costs or prices that are static – in other words, the prices remain unchanged within the rating period regardless of what happens with underlying system operations.

Peak Time Rebates (PTR) in many cases provide a fixed critical peak price dispatchable within a fixed time period, only on a select number of days each year. Many PTR rates are built on a flat rate with no peak or off-peak time variation. PTR rates without basic time-of-use variation do not provide support for load shifting, solar, storage, PHEV's or carbon reduction initiatives.

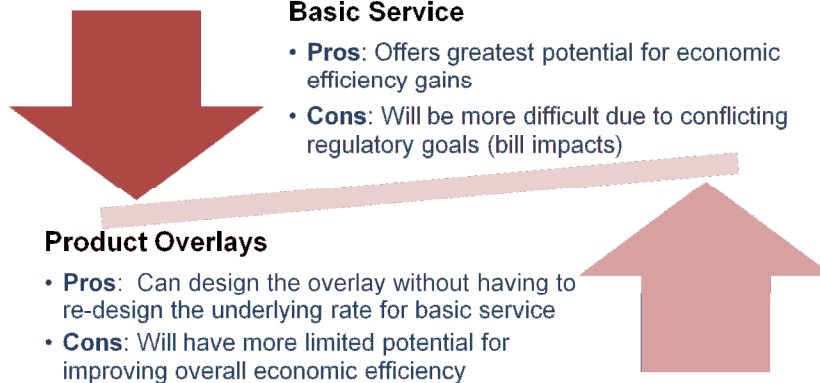
Critical Peak Pricing (CPP) can exist in two forms, both of which are typically built on a TOU base rate. One form of CPP provides a fixed critical peak price dispatchable within a fixed time period, only on a select number of days, which is considered the antithesis to PTR. CPP on a TOU base rate can provide the time varying costs necessary to support other renewable and load shifting initiatives. The second form of CPP (e.g. Gulf Power) removes the fixed day and fixed time period restrictions, allowing a pre-defined critical peak price to be dispatched for durations compatible with system economic or reliability conditions at any hour throughout the year on both a day-ahead and day-of basis.

Real-time pricing (RTP) eliminates artificial rate period and other restrictions, allowing the price to vary at a variety of time intervals (15, 30 or 60 minutes).

## 5.44 Rate Design



### Issue #3: What type of Rate Design ?



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Slides 5.12 through 5.18 discussed the differences between basic rate forms and product overlays.

Most of the pilots / treatments conducted by utilities over the last ten years (Slide 5.21) have successfully used CPP or PTR overlays on top of time-of-use, inclining block, or flat rates. The success of these pilot results make a strong case for overlays. Overlays can also provide flexibility by establishing a degree of independence between the base price signals (default service) and critical price signals. This independence would allow the base and critical price signals to adapt separately to address changing system conditions. Based on system and market conditions, different overlays could also be developed and targeted to sub-populations of customers to reflect varying system reliability and congestion factors. As a result, overlays may also simplify or reduce the scope and complexity of a rate case proceeding.

The basic advantage for redesigning the default service is that it provides the potential for the greatest efficiency gains (e.g. if a TOU rate is adopted), however if this rate is substantially different from the existing default service – it will provide more substantial bill impacts and customer issues.

## 5.45 Rate Design



### Issue #4: Mandatory or Voluntary Participation ?

- ❑ **Mandatory Rates (new default rate, no opt-out)**
  - **Pros:** Likely to achieve the largest overall economic benefits
  - **Cons:** Potential for windfall gains and losses and customer opposition
- ❑ **Mandatory Assignment (with an Opt-out provision)**
  - **Pros:**
    - a) “Nudges” people onto more efficient rate structure,
    - b) Preserves customer choice , and
    - c) Reduces marketing and recruitment costs
    - d) Creates larger potential market to enable smart appliances, energy management options, and competitive pricing
  - **Cons:** might have customers migrate in larger numbers if prices change
- ❑ **Voluntary Rates (targeted recruitment)**
  - **Pros:** Reduces potential windfall losses and customer opposition.
  - **Cons:** Self-selection bias and potential moral hazard issues.

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The issue of mandatory versus voluntary participation raises some of the strongest and most volatile issues related to rate implementation.

Mandatory or default rates come in two flavors – with and without opt-out options.

Mandatory or default rates without opt-out options are unlikely due to the potential for adverse customer reaction, even considering the potential efficiency gains.

Mandatory or default rates with opt-out options are substantively very similar to voluntary rates, which by definition imply customer options. Both approaches may include the exact same rate options. Both approaches preserve customer choice. The primary difference – default rates with opt-out subtly take advantage of customer tendencies to “not change” what they do unless there is a compelling set of circumstances. In other words, a default rate with opt-out would take advantage of customer inertia. Field studies in many different industries tend to show that a default opt-out arrangement may result in about 50-70 percent of the customers staying on the default rate. Utilities that have aggressively marketed TOU rates on an opt-in basis (e.g. Salt River Project, APS) have been able to achieve ~20-30% participation rates after many years; participation rates are much lower for other types of dynamic pricing tariffs.

The default opt-out approach reduces customer recruitment and marketing efforts, the costs associated with those efforts, focusing instead on customer education. Larger initial customer participant populations also have positive implications for creating larger markets, more innovation, and lower costs for automation technologies and competitive pricing. The default approach will also create a larger pool of customers capable of addressing distribution congestion management applications.

## 5.46 Rate Design



### Issue #5: Low Income / Senior Bill Impacts?

- ☐ Impacts can be modeled in advance
- ☐ Resistance may be a function of customer education, uncertainty, and clear mitigation options
- ☐ Rate design can be structured with efficiency, appliance rebates, other programs and policy initiatives to provide mitigation options.

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Next to the mandatory-voluntary issues, bill impacts for low income and senior citizen customers is near the top of the controversial issues.

Once advanced metering is in place, the actual expected bill impacts for each customer can be modeled in advance based on their actual usage patterns. In fact, this is an implicit assumption underlying the value of 'shadow bill'. Being able to calculate and compare the customer bill under the actual rate provides just the information necessary to identify if there is a potential problem or issue.

Shadow billing allows customers with adverse or unacceptable bill impacts to be individually identified and targeted for a variety of mitigation measures. Mitigation could include targeted energy audits, bundling of appliance rebate and other subsidies to accelerate the purchase of more efficient appliances, or recommendations to move the customer to non-dynamic rates with less volatility.

Structural bill impacts due to lifestyle patterns that the customer won't or can't change and difficult to change housing and appliance stocks will remain an issue. One of the objectives of dynamic rates is to more equitably allocate costs among customers based on usage patterns. Some classes of disadvantaged customers may require special regulatory treatment if conventional programmatic or mitigation measures are insufficient.

The individual rate impacts for low income and seniors very much depends upon their existing pre-dynamic rate and usage patterns.

## 5.47 Rate Design



### Issue #6: What don't we know ?

- ☐ Will customer response behavior persist or erode over time?
- ☐ How can the results from one utility be extrapolated to other regions with different climate, economics, and customer mix?
- ☐ What types of education, communication, and enabling technology will work best to improve customer response?
- ☐ Will more pilots address unresolved issues or is a staged implementation a better approach?

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After 10-15+ years of dynamic pricing pilots, there is still a very long list of things we don't yet have answers to.

One of the risks inherent in this list of factors is the expectation that there are or will be explicit answers for each question. That may not be the case. However, if the system needs only fall into the 5-8% range identified by the superimposed yellow band, then this slide actually provides certainty and a low risk, not uncertainty.

One of the tendencies of uncertainty is the need to commission and seek out additional pilots. While there is a role for additional scientific and economic study, there are substantial issues that pilots cannot address, specifically:

- Thus far, few dynamic pricing pilots have addressed the price threshold issue – what minimum peak to off-peak price differential is necessary to obtain a system optimum peak load reduction? It is challenging for pilot programs to make this determination because of the complexity of testing multiple price points and/or creating many treatment groups.
- None of the existing dynamic pricing pilots have addressed long-term customer adaptation to price that requires a commitment to invest funds in major home or business improvements, appliance upgrades, and renewables or generation alternatives. Again, it is unlikely that any pilot can make this determination because it would require a test period of at least 5-8 years.
- Finally, the political and practical reluctance to implement mandatory pilots with no opt-out provisions will always leave in doubt a component of customer acceptance.



## 5.50 Rate Design



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	Title	Link
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2	Department of Energy Smart Grid Investment Grant Consumer Behavior Study Plans	<a href="http://www.smartgrid.gov/sites/default/files/pdfs/rate_design.pdf">http://www.smartgrid.gov/sites/default/files/pdfs/rate_design.pdf</a>
3	"Demand Response Best Practices, Design Guidelines and Standards", Lawrence Berkeley National Laboratory Demand Response Research Center, June 11, 2008.	Presentation to the California Public Utilities Commission, December 2008
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